German Energy Regulation and Asset Prices

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Abstract: The German Federal Network Agency (FNA) issued regulations concerning the valuation of gas and electricity transmission networks. For this purpose the FNA developed a formula of a mixed price index combining prices of labour and materials faced by producers of such assets. A problematic feature of the index is how it accounts for rising labour productivity. It is called in question that this index adequately reflects the economic value of such networks used as inputs by the providers of network services. Moreover the index was an instrument under the regime of a relatively simple regulation. In the case of incentive regulation a need will be for statistical work of much more subtlety. The paper may be viewed as a case study demonstrating some statistical problems in the legal fields of competition and regulation law.

1. Introduction

Owners of energy transmission networks are said to enjoy a "natural monopoly" - because it is as a rule not possible to build and operate competing networks in a country - and the "line business" may therefore be tempted to misuse market power. This gave rise to regulatory activities in many countries as a government function.[1] Regulatory agencies were established and we are used to regard them as serving some valuable general purposes. In this country the relevant body is known as the German Federal Network Agency (FNA for short).[2]

Regulation refers in the first place to prices and the supply side of the market. The FNA therefore describes its mandate as follows: "to establish fair and effective competition in the supply of electricity and gas by ensuring non-discriminatory third-party access to networks and policing the use-of-system charges levied by market players."

Therefore the FNA has been given the power to take binding decisions which may possibly profoundly affect price formation mechanisms and thereby competition and long term investment decisions in the energy sector. Decisions affecting prices and profitability are also within the scope of the FNA's legislation.[3] In this paper some decisions of the FNA concerning prices[4] are discussed and criticized from a statistical point of view.

The scope and method of regulation changed, however, considerably with the passage of time, and the problems considered in what follows are related to a rather early "state of the art" of regulation, viz. cost regulation, where prices (in this case the above mentioned "use-of-system charges") are set in such a way that they may cover the cost of operation and capital and provide in addition a certain margin of profits. This sort of regulation may reasonably be questioned on the ground that it does not (or not sufficiently) provide incentives to reduce cost and to implement maybe expensive technological innovations. The following considerations are dealing with a problem ensued from this rather simple and crude "regime" of cost regulation,

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[1] It should be borne in mind that, in principle at least, rules can also (and usually will also not infrequently) be established through voluntary action.

[2] or "Bundesnetzagentur (BNetzA)" in German.

[3] It is of course clear that regulation can well do more harm than good, if for example the regulation policy fails to constitute the (long term) correct incentives. Regulators therefore developed a number of different (and perhaps increasingly more sophisticated) approaches. However, this is not our concern here. The point here is to compile a price index in a situation in which no information is given concerning the producer prices actually obtained in the market place and where it may be sensible to combine somehow official price indices measuring various cost components in order to reflect the rising level of costs producers are facing.

[4] As will be shown later, they materialized in a price-index-formula, and they date back already to August (electricity) and September (gas) 2007.

or total cost benchmarking (in Germany) prevailing in many countries some years ago and we contrast this situation briefly with a much more sophisticated methodology adopted under the regime of "incentive regulation" for which we give one example only (a study referring to New Zealand).[5]

It is well known that for economists the interesting problems of regulation are among other things its implications for competition, private initiative and perhaps the not unlikely and unfavourable perspective of heading to more and more interventionism. It may also be doubtful whether we really have a market failure which may justify interventions because such interventions may bring more costs than benefits, and seem to be built on the doubtful (as will be seen also in this paper) assumption of omniscient government regulatory bodies.

Much less awareness may exist concerning the statistical and econometrical challenges involved in regulation, even under the regime of a relatively unassuming cost regulation, let alone in the framework of a more (and increasingly) sophisticated incentive regulation, which is nowadays becoming the standard.

The problem dealt with in this paper is to compile a price index of an asset like a large (nationwide) "grid" for. It arose from my work[6] as a statistician and consultant of a great private owner of a gas and electricity transmission network in Germany and its main result is part of the plaintiff's statement in a lawsuit against our national regulation agency, the FNA.

The following text starts with a short presentation of a price index developed by the FNA (section 2). We there already highlight some differences between the German approach and a statistical study undertaken for the (electricity) regulation in New Zealand. In section 3 I show how the FNA itself tried to justify its approach and how I think, the index formula of the FNA could be derived and justified formally (the FNA made no attempt of this kind). Section 4 criticises this approach by showing what is tacitly implied (in terms of an underlying production function). Section 5 concludes and adds a synoptic table in which the method of the FNA which I criticized in the present paper is contrasted with the method in a paper[7] applying to New Zealand.

2. The price index for transmission networks of the FNA

The FNA developed a price index in order to measure the actual market value (or "net present value")[8] of an energy network. This index basically aims at reflecting the production costs one would have to pay today for re-buying such grids, which actually had been erected many years ago and which are still in use. As our German official statistics presently does not (and actually never did) provide a suitable price index for precisely this sort of assets the FNA faced the task to define such an index on her own by using official price and wage indices as building blocs. The solution of the agency was an asset price index P_t as a weighted average

[5] My presentation in this point relies on D. Lawrence and W. E. Diewert (2006), "Regulating Electricity Networks: The ABC of Setting X in New Zealand", in Chapter 8 *Performance Measurement and Regulation of Network Utilities*, T. Coelli and D. Lawrence (eds.), Cheltenham: Edward Elgar Publishing, pp. 207-241. I got this "Lawrence/Diewert paper" from W. Erwin Diewert, and it is my main source of the method, I am going to contrast to the FNA method in this present paper. Other references referring to "incentive regulation" can of course easily be added. My other sources to which I refer in this paper are primarily own works, in particular the unpublished expertise commissioned by the energy network owner. Of these works (in German) one reference may be quoted here as it concisely summarizes some views expressed in this paper: P. v. d. Lippe, Preisindizes der Bundesnetzagentur, Wirtschaftsdienst 1/2009, pp. 64 – 72.

[6] It took place already in winter 2007, however, the lawsuit against the FNA is still ongoing today (March 2011).

[7] It is quoted as "Lawrence/Diewert paper" in footnote 5.

[8] "Tagesneuwert".

of an index of wages (λ_t, representing the factor "labour")[9] and "materials"[10] (μ_t as part of the German PPI) that is

(1) $P_t = w_L\lambda_t + w_M\mu_t$ (where $w_L + w_M = 1$).

It is important to note that the intention of this price index is to mirror the production *costs of producers* of energy transmission networks *as opposed to reflecting the economic value the networks represent for the line business*, for which in particular future demand for (and profitability of) network services is decisive. So P_t assumes the perspective of producers of network components (their output and *their labour productivity*) rather than the perspective of users, i.e. the "line business" where these goods are used as inputs. This is already one of the fundamental differences between the German approach and the one of New Zealand, where the focus is on output, input and total factor (not only labour) productivity[11] *of the line business* as these firms (rather than producers of network constructions, materials and equipments) are subject to regulation.

In what follows for my theoretical discussion of the FNA approach (that is eq. 1)[12] I will assume that the index λ_t is a ratio of absolute wage levels L so that $\lambda_t = L_t/L_0$ (correspondingly $\mu_t = M_t/M_0$), just like a single price relative.[13]

The FNA claimed that they had found empirically weights $w_L = 0.4$ and $w_M = 0.6$ for the year t = 2006, however, they did not give details about how they managed to find these figures and why they had been – as they said – unable to find such weights for years other than 2006 (they also argued, they were even unable to provide data to check the plausibility of the FNA index against data of actual purchases of the industry or alternative estimates presented by the line business).[14]

There was much debate on the part of the grid owners as plaintiffs about whether costs of the network producing industry adequately reflect the true economic value of energy grids, and whether the selected sub-indices of labour λ_t and materials μ_t respectively really correctly cover the kind of work or goods in question. It was argued that it is far from clear to which sector the specific λ and μ index for a certain asset (facilities and equipments of energy nets) should refer. Should wages and prices be chosen that refer for example to the sector construction (section F in the NACE classification) or rather to the more comprehensive sector of the production industries.[15]

[9] In what follows we use the term "wage" to denote both, wages as well as salaries.

[10] The intermediate consumption meant here should usually comprise raw materials and supplies as well as energy; however, it seems to me that the FNA only took goods serving as raw material into account.

[11] Relevant was also (at least for a temporary adjustment and alignment process of) the profitability and competitiveness of suppliers. This implies also a benchmarking procedure comparing individual firms which was not inherent in the FNA approach underlying the regulation of asset-pricing of autumn 2007 which is our objective in the present paper.

[12] eq. stands for equation.

[13] Strictly speaking this assumption is not realistic, however, because a price index is a (weighted) mean of *a number of* n > 1 price relatives, whereas a price relative compares the price (in absolute terms) of a single commodity i (i = 1, …, n) in two periods, 0 (base period) and t (current period) p_{it}/p_{i0}. So we assume a situation of a single price relative (as ratio of absolute prices) while λ_t and μ_t are in fact price indices.

[14] The industry requested such plausibility controls which where turned down by the FNA as allegedly impracticable due to lack of data (which, however, did not apply to the empirical foundation of weights w_L and w_M). The FNA also argued that even if they were feasible they would nonetheless not be valid. On the other hand the agency implicitly claimed validity of her formula although she could not see how plausibility possibly could be checked.

[15] The "goods producing industries" comprise in addition to F (construction) also the sections B (mining and quarrying), C (manufacturing) and D (electricity, gas, steam and air conditioning supply).

Also contentious was why capital cost was excluded from this index P. This, however, is not my point in the present paper although much (or most) of this kind of criticism clearly sounds reasonable and worth being discussed in detail.[16]

What the paper is focused on instead is another topic, viz. the FNA's method to take into account the undeniable (and probably also labour saving) technical progress in producing energy transmission networks. The FNA did so by simply "down weighting" one of the components (that is the weight w_L of wages λ_t) while keeping the weight w_M of the other component (μ_t) constant. So the FNA "invented" the following producer price index P_t of energy grids

(2) $$P_t = \frac{w_L}{\pi_t} \cdot \lambda_t + w_M \cdot \mu_t = \omega_L \lambda_t + w_M \mu_t,$$

where $\omega_L = w_L/\pi_t$ and data were used of the official German Statistics for the indices λ_t, μ_t, and π_t. Hence the FNA simply divided w_L by an index π_t of labour productivity, in order to establish an "adjusted" weight $\omega_L = w_L/\pi_t$ (such that $\omega_L + w_M \neq w_L + w_M = 1$) for λ_t. The agency only later realized that this approach is equivalent to using "unit labour costs" $\kappa_t = \lambda_t/\pi_t$ instead of the official wage index λ_t, because

(2a) $$P_t = w_L \kappa_t + w_M \mu_t.$$

Obviously the index P_t is a weighted mean of unit labour costs and prices (not unit costs) of materials while it is no longer a mean of the official wage index λ_t and the PPI-price index μ_t (because $\omega_L \neq w_L$) so that it may violate the mean value property $\mu_t < P_t < \lambda_t$ or (less likely) $\mu_t > P_t > \lambda_t$.[17]

It is important to note that (2) means that only labour productivity π_t. is accounted for and the one-sided adjustment of one weight only is our main criticism. By contrast we see in the Lawrence/Diewert paper in which the method of New Zealand was developed, that an estimate is made of the total factor productivity (TFP), comprising all inputs, not only labour.

Given that the energy supply assets are usable over a long period in time it is clear that we have an index problem with rather long time series involved, and that both, λ_t and μ_t are represented by a number of indices with different base years, and which therefore have to be linked together. It is of course also clear and generally agreed upon that the weights w_L and w_M will vary over the period of fifty and more years which is the time span under consideration here. I do not argue in favour of constant weights w_L and $w_M = 1 - w_L$ over such a long time. My point only is that an isolated change of one weight ($w_L \to \omega_L$) "ceteris paribus" in a composite of two indices appears objectionable as it implies a rather odd and awkward underlying production function (see section 4).[18]

3. How the FNA formula can be justified

The index according to (2) or (2a) is admittedly the agency's own invention (I did not find something remotely similar anywhere else in German official statistic). So we start with asking how the FNA herself justified its formula. The FNA offered in principle three arguments in favour of its formula (and the different treatment of L and M in particular). The first reveals

[16] As will be shown later capital costs in particular – interestingly seen as a sort of input – was indeed a most influential component of the statistics developed for regulation purposes in New Zealand.

[17] In my view violation of this mean value property seems to be a significant shortcoming of the FNA's formula. It is for example difficult to understand why the price of a good should rise by say only 10% while input prices are rising by 20% and 30% (if for example $\mu_t = 1.2$ and $\lambda_t = 1.3$).

[18] The correct procedure would be an empirical revision of *all* weights, w_L as well as w_M in certain intervals (at five years or annually with chainlinking) which would also result in weights for λ_t and μ_t that add up to unity for all time periods $t = 0, 1, \ldots, T$. It is also common to use expenditure shares for w_L and w_M respectively.

a deplorable incompetence in index theory. It goes as follows: wages are already measured in Euro per hour (€/h), while prices of materials are reported in Euro per unit (number of items) €/n, and so labour productivity defined in terms of units per hour (n/h) – which by the way is not correct – is needed to make a wage index commensurable to μ_t and P_t (measured in €/n). The FNA believed the equation in the respective dimensions $\frac{€/h}{n/h} = \frac{€}{n}$ exists as counterpart of the division of λ_t by π_t. It obviously was not known that an index has no dimension and is not a figure expressed in absolute monetary terms (€ or $). Some doubts should have occurred to the FNA if they have had looked at the kind and variety of goods and services combined in a CPI for example, and why to date nobody ever have had the idea to search for a common quantity unit to which prices for goods like bus ride, hair cut, potatoes, beer, monthly rent of a flat or a driving license may refer.

The second argument sounds a bit more sophisticated. It was argued that the labour productivity reflects a substitution process. When (more) x substitutes, or replaces (now less) y it is clear what is meant by "substitution". The FNA, however, nowhere made clear what is x and what is y in this case, that is what substitutes labour. The agency simply maintained that we now use less labour only, but did not reflect how and at what costs this came about. It was particularly ruled out that more capital was needed for a "substitution" of labour because capital costs were deliberately excluded from the formula (2) for P_t.

The third and final argument was built on the idea that there is a fundamental difference or asymmetry between price indices (for goods) and wage indices (for the production factor "labour"). The FNA repeatedly argued that technical progress (materialized in a rising labour productivity) is already accounted for in official price indices whereas official wage indices are not "adjusted" accordingly and it is left to the user to make the necessary "corrections". The index λ_t is an "index of agreed wages and salaries"[19] (based on about 550 selected collective agreements between unions and employers associations in Germany). According to the FNA λ_t is "biased" upwards as it does not account for an increased labour productivity, and therefore unit labour costs κ_t have to be preferred over λ_t as element of a price index (which by the way should reflect the "pure" price movement[20] in both cases, prices of factors as well as goods).

It is beyond the scope of this paper to rebut this argument because it would be of statistical interest only.[21]

We now show how a formula for the index P_t (like eq. 2) could be derived formally. For this purpose it is useful to introduce some symbols. Assume two periods 0 (base period) and t (current period) respectively, and the following prices and quantities in 0 (and t) as *absolute* figures (prices in € for example or labour in terms of hours (h) worked so that wage is €/h)

[19] Also called "contractual wages and salaries".

[20] A fundamental principle of price statistics is that a price index should reflect the price component independent of quantity movements (as they ma occur in response to price changes). This is meant by "pure" price comparison.

[21] It should suffice to note that I nowhere found a statements of our Federal Statistical Office (FSO) of this sort saying that λ_t (wages) tends to overstate the price of labour by contrast to κ_t (unit labour costs) which then indeed would support the FNA's view. If the position of the FNA were correct some obvious questions may be asked, such as: Why does the FSO publish in the case of labour two indices, a biased (and – allegedly - unadjusted for quality change) one (λ_t) and an adjusted one (κ_t) while in the case prices for goods, we only have one type of index, viz. the quality adjusted one? Or: If λ_t is biased why do we need λ_t in addition to the unbiased κ_t?

	labour		materials*		final product	
	0	t	0	t	0	t
quantity	B_0	B_t	V_0	V_t	X_0	X_t
price	L_0	L_t	M_0	M_t	p_0	p_t
price index	$\lambda_t = L_t/L_0$		$\mu_t = M_t/M_0$		$p_t = P_t/P_0$	

* intermediate consumption

** "quantity" is here the number of "network units" which may sound a bit odd (the exact meaning of "units" here may be left open)

Then equality of sales-value (revenues) and total costs in period 0 means

(3) $X_0p_0 = B_0L_0 + V_0M_0$ and correspondingly in t we have

(4) $X_tp_t = B_tL_t + V_tM_t$.

From this it follows that

(5) $$p_t = \frac{1}{X_t / B_t} L_t + \frac{1}{X_t / V_t} M_t$$

and using labour productivity $X_t/B_t = \Pi_t$ and productivity of materials $N_t = X_t/V_t$ we get

(5a) $$p_t = \frac{1}{\Pi_t}\lambda_t L_0 + \frac{1}{N_t}\mu_t M_0 = \frac{1}{\Pi_t}\cdot L_t + \frac{1}{N_t}\cdot M_t .$$

Division of (5a) by p_0 gives $P_t = \frac{p_t}{p_0} = \frac{1}{\Pi_t}\cdot\frac{L_0}{p_0}\cdot\lambda_t + \frac{1}{N_t}\cdot\frac{M_0}{p_0}\cdot\mu_t$

We now also introduce *indices* of the *change* of productivity viz. $\pi_t = \Pi_t/\Pi_0$ and $\nu_t = N_t/N_0$ and upon defining $w_L = \frac{L_0}{\Pi_0 p_0} = \frac{B_0 L_0}{X_0 p_0}$ and $w_M = 1 - w_L = \frac{M_0}{N_0 p_0} = \frac{V_0 M_0}{X_0 p_0}$ we get

(6) $$P_t = \frac{w_L}{\pi_t}\cdot\lambda_t + \frac{w_M}{\nu_t}\cdot\mu_t = \omega_L\lambda_t + \omega_M\mu_t .$$

Note that the weights $\omega_L = w_L/\pi_t = B_0L_t/P_0X_t$ and $\omega_M = w_M/\nu_t = M_0V_t/P_0X_t$ do not add up to unity. With κ_t and unit-cost of materials $\theta_t = \mu_t/\nu_t$ we have, however, a true weighted average

(6a) $P_t = w_L\kappa_t + w_M\theta_t$.

The difference between this formula and the FNA-index (2) is that the FNA implicitly assumed $\nu_t = 1$ or $N_t = N_0$ (or equivalently $\theta_t = \mu_t$).[22] It is precisely this assumption $\nu_t = 1$ which is pivotal for our criticism of the FNA approach to define an asset price index.[23]

4. The implicit production function of the FNA formula

It turns out that with some simple transformation of definitions we are able to demonstrate clearly enough the implications of the assumption $N_t = N_0$. From a rising labour productivity $\pi_t > 1$ and at the same time a constant productivity of materials $\nu_t = 1$ follows

[22] It can easily be seen that if and only if $\nu_t = 1$ holds equations 6 and 6a reduce to (2) and (2a) respectively.

[23] In the following section our task will be to unfold the implications and consequences of this very assumption. The focus is on the FNA formula only. We do not consider here in detail other possible formulas using λ_t and μ_t and various weights (variable and constant), as for example a direct (or chained) Laspeyres or Paasche index of input prices or an index using as weighted mean of unit-labour costs (ULC) $\kappa_t = \lambda_t/\pi_t$ and the (somewhat unfamiliar) unit costs of materials (UMC) $\theta_t = \mu_t/\nu_t$.

(7) $$\frac{X_t}{X_0} = \frac{V_t}{V_0},$$

and this equation simply means, that output growth is determined solely by more or less input of materials, while labour input B_t as well as labour productivity π_t are completely irrelevant. This sounds strange enough. Moreover as V_0 and X_0 are constants $N_0 = X_0/V_0 = c_1$ is a constant as well, then $\nu_t = 1$ simply implies the following rather odd production function

(8) $$X_t = N_0 V_t = c_1 V_t.$$

This shows again that both, B_t and π_t are irrelevant for the output X_t. These variables will, however, together with input prices L_t and M_t influence the price p_t of the output. Using (8) we get with

(5b) $$p_t = \frac{1}{\Pi_t} \cdot L_t + \frac{1}{N_0} \cdot M_t$$

instead of (5a), an equation which basically serves the same purpose as (2).

To make the implications of the rather restrictive production function (8) clearer it may be useful to consider now an illustrative numerical example. The point in this example is that here the FNA formula in fact perfectly predicts the true price change.

Example 1

	X	p	X p	B	L	V	M	X/B = Π	X/V = N
0	100	30	3000	60	20	60	30	100/60 = 1.67	100/60 = 1.67
t = 1	150	40	6000	50	40	90	44.44*	150/50 = 3	150/90 = 1.67

* or more precisely 400/9

Evidently output increased by 50% (as $X_0 = 100$ and $X_t = 150$) just like the intermediate consumption V did (because $V_t/V_0 = 90/60 = 1.5$). Note that $w_L = 0.4$ and $w_M = 0.6$ and the prices changed as follows $p_t = 40/30 = 1.333$, $\lambda_t = 40/20 = 2$ and $\mu_t = 44.44/30 = (400/9)/30 = 400/270 = 1{,}48148$. Labour productivity rose by 80% ($\pi_t = 3/1.667 = 1.8$). It can easily be seen that under such conditions (as in fact $\nu_t = 1$) the FNA-formula is correct because

$$P_t = \frac{0.4}{1.8} \cdot \lambda_t + 0.6 \cdot \mu_t = \frac{4}{9} + \frac{8}{9} = \frac{12}{9} = 1.333$$

However, the mean value condition is violated because $1.333 < \mu_t = 1.48 < \lambda_t = 2$. By contrast a Laspeyres approach would yield $P_t^L = 0.4\lambda_t + 0.6\mu_t = 12/9 = 1.6889$ (P_t then should be 50.67 instead of 40).[24]

The underlying production function of the type (8) is in this first example

(8a) $$X_t = f_1(B_t, V_t) = (5/3)V_t = 1.667V_t = c_1 V_t.$$

so that X_t simply is proportional to V_t. It follows from above that for any other production function than just $X_t = c_1 V_t$ the FNA formula will *not* hold true.

Now consider a variant of example 1 in which the underlying function is given by

(9) $$X_t = \frac{5}{3} V_t + \frac{7}{3} B_t = c_1 V_t + c_2 B_t$$

[24] The Laspeyres approach gives $(B_0L_t+V_0M_t)/(B_0L_0+V_0M_0) = 1.689$, and the Paasche formula in this case is given by $(B_tL_t+V_tM_t)/(B_tL_0+V_tM_0) = 1.6217$

instead of (8a). It is only with respect to c_2B_t that (9) differs from (8a). We leave the shaded parts in the table for example 1 unchanged and therefore also the expenditures

(3a) $X_0p_0 = B_0L_0 + V_0M_0 = 1200 + 1800 = 3000$ and

(4a) $X_tp_t = B_tL_t + V_tM_t = 6000$,

so that the (base period) weights $w_L = 0.4$ and w_M, $= 0.6$ remain unchanged too. Hence the modified assumptions are:

Example 2

	X	p = Xp/X	X p	X/B = Π	X/V = N
0	240	12.5	3000	240/60 = 4	240/60 = 4
t = 1	880/3*	20.45**	6000	293.33/50 = 5.867	293.22/90 = 3.259

* = 293.33
** rounded

Note that due to the different production function it is primarily X_0 and X_t (and therefore also the productivities) which differ from the first example. We get $X_0 = 60c_1 + 60c_2 = 240$ and $X_t = 50c_1 + 90c_2 = 880/3 = 293.33$ instead of $X_0 = 100$ and $X_t = 150$ respectively. The price change amounts to $P_t = p_t/p_0 = 20.45/12.5 = 1.63636$ and we get exactly this result for P_t using (6) or (6a).

Productivity changed as follows: $\pi_t = 5.867/4 = 1.4667$ and $\nu_t = 3.259/4 = 0.8148$ which explains the difference between weights (ω_L, ω_M) and weights (w_L, w_M). on the one hand and unit costs (κ_t, θ_t) and factor price indices (λ_t, μ_t) on the other.

Now consider the FNA-formula. The part $w_M\mu_t = 8/9 = 0.888$ remains unchanged (compared to example 1) and therefore we get according to (2) and (2a)

$$P_t^{FNA} = (0.4/1.4667)\cdot 2 + 0.8888 = 1.434343 < 1.63636.$$

Hence the FNA formula understates the price movement because it does not take into account that $\theta_t = \mu_t/\nu_t = 1.4815/0.8148 = 1.8181 > \mu_t = 1.4667$ because $\nu_t = 0.8148 < 1$ (productivity of materials decreased as productivity of labour increased).[25]

Digression

Finally a more formal statement of the nature of the underlying production functions (8a) and (9) respectively goes as follows. It is clear that they both are linear homogeneous production functions (with constant returns to scale) which means that (assuming a sufficiently small interval between the points in time 0 and t) we get

(10) $$\begin{bmatrix} B_0 & V_0 \\ B_t & V_t \end{bmatrix} \cdot \begin{bmatrix} \partial X/\partial B \\ \partial X/\partial V \end{bmatrix} = \begin{bmatrix} X_0 \\ X_t \end{bmatrix}$$

or equivalently $dX = \frac{\partial X}{\partial B}dB + \frac{\partial X}{\partial V}dV$. And this means with the figures of example 1

$\begin{bmatrix} 60 & 60 \\ 50 & 90 \end{bmatrix} \cdot \begin{bmatrix} \partial X/\partial B \\ \partial X/\partial V \end{bmatrix} = \begin{bmatrix} 100 \\ 150 \end{bmatrix}$ such that the marginal productivity of labour turns out to be zero

[25] The indices of Laspeyres and Paasche are functions only of quantities (B and V) and prices (L and M) of the two production factors. None of these figures has been changed. Thus there is no difference between the two examples in this respect. However, the results now come much closer to the correct figure 1.63636 than in the first example where a somewhat awkward production function (11a) was assumed

$$\partial X/\partial B = \frac{\begin{vmatrix} 100 & 60 \\ 150 & 90 \end{vmatrix}}{\begin{vmatrix} 60 & 60 \\ 50 & 90 \end{vmatrix}} = \frac{0}{2400} = 0 \text{ as opposed to the positive } \partial X/\partial V = \frac{4000}{2400} = \frac{5}{3}.$$

The result of the second example sounds much more reasonable. The difference is due to the vector $\begin{bmatrix} X_0 \\ X_t \end{bmatrix} = \begin{bmatrix} 240 \\ 266{,}67 \end{bmatrix}$ instead of $\begin{bmatrix} 100 \\ 150 \end{bmatrix}$, so that we get in this case $\partial X/\partial B = \frac{5600}{2400} = \frac{7}{3} = c_1$ and $\partial X/\partial V = \frac{4000}{2400} = \frac{5}{3} = c_2$ which of course already follows from (9).[26] Note that given the production function (9) the formula (6) and (6a) respectively seem to be correct as they correctly account for the rising labour productivity ($\pi_t = 1.4667$) and declining productivity of materials ($\nu_t = 0.8148$) whereas the FNA formula (2) clearly proves to be wrong.

5. Conclusion

To sum up, it turns out that regulation – even in the case of the comparatively simple supervision of costs and pricing according to (average) costs – some interesting statistical problems emerge. The way the FNA tackled these index problems in particular seems to be anything but satisfactory. The most critical feature of the index formula of the FNA is arguably the isolated and quasi automatic (using the index of labour productivity π_t) "correction" of one of the two weights only. I tried to demonstrate that this is not tenable by showing what this isolated correction of one weight only might mean in terms of an implicit production function. It could be shown that this function is odd and implausible in that it implies a zero marginal productivity of labour and an output independent of the amount of labour input.

This comparatively poor performance as regards statistical reasoning has to be seen against the backdrop of what has been done in other countries in this respect and also in view of the recent developments of regulation methods. These methods, such as "incentive regulation" are much more demanding regarding statistical expertise.

The following final synoptic table – comparing a New Zealand approach to the German approach – may illustrate that regulation of line businesses can be much more sophisticated than what has been done in Germany in the case of the contentious regulation of asset pricing in gas and electricity transmission networks.

[26] To make the discussion here shorter and more readable we refrain from presenting analogous considerations using more general production functions such as the Cobb Douglas function with constant returns to scale and alternatively a function with disembodied technical progress at a constant rate. These considerations clearly once more confirm our critique of the FNA formula. Also for such more general production function the assumptions $\pi_t > 1$ and at the same time $\nu_t = 1$ turn out to be contradictory.

Difference between the approach of the German Federal Network Agency (FNA) and Lawrence/Diewert

Subject	Lawrence/Diewert	German FNA
Principal objective of the task	Incentive regulation (CPI-X approach) of prices in New Zealand electricity lines business, i.e. methods to set a maximum change of output prices while also providing incentives to cut costs and enable the below average firms to catch-up	Updating of asset valuations in electricity and gas network firms using a price index which is meant to reflect production costs of the respective assets; no incentive regulation, no benchmarking and inter-industry comparisons intended
The sector on which the focus lies	Production (costs, productivity) of services provided by the transmission and distribution businesses; comparisons between firm and economy wide growths and levels of performance parameters	Prices in producing new assets (lines, constructions, equipments etc.); focus on the supply side only, not on the demand on the part of transmission network owners (or on their performance parameters)
End product of the task	Definition of factors (B, C1, C2) [1] to be applied in the framework of price setting for electricity suppliers, based on average (economy wide) and relative (firm specific) level and growth of productivity and also (for C2) profitability	Definition of a price index (reflecting dynamics in producer prices) for producing assets in order to inflate or deflate the economic value of transmission facilities. No data of line businesses considered, only official price and wage indices.
Output	Three kinds of output (throughput, capacity, number of connections), aggregated using weights gained from a cost function	No indicators of real output of asset producers, much less of the service as the output of the owners of transmission nets
Input	Quantities and prices of five types of inputs: operating expenses (OpEx, including labour and materials), and various assets (stocks), e.g. overhead and underground network etc. "Direct physical assets measures"[2] were preferred to simply updating given valuations of assets	Index combines prices of labour (wages) and materials only; not clear how weights for these respective sub-indices were derived. No OpEx or other costs incurred in the line businesses (in particular no estimates of the "amount" of assets). Index serves to update valuations of assets.
Productivity	Total factor productivity (TFP) defined as ratio of chained Fisher quantity indexes of output and (total) input (also partial TFPs for the five types of inputs)	Only labour productivity (of the commodities producing sectors and construction sectors) to (solely) "adjust" the weight of wages in the index
Econometric estimates	Estimation of input demand equations (input quantities depending on output and time trend) within the framework of cost functions (separately for each firm)[3]	No estimation of asset or other input requirements in order to satisfy demand for transmission services. No econometric work at all on the part of the FNA known
Problems in methodology	In order to make transitive comparisons of productivity levels: CCD-indices[4]	All in all method was econometrically anything but sophisticated

1) The factors B, C1 and C2 are meant as targets to strive for. The "B-factor" is reflecting industry-wide (line business) total factor productivity (TFP) growth, C1 is reflecting comparative productivity performance (of a firm relative to the industry) and C2 refers to the relative profitability (a variable of temporary significance only for the time needed for catch-up).

2) Estimation of physical quantities of the principal assets

3) Such cost function were used to provide weights for aggregating the three output components

4) CCD stands for Caves-Christensen-Diewert and refers to Törnqvist indices transformed in a way to allow transitive multilateral (here across firms) comparisons. Transitivity of economic measures (such as indices, or parameters like B, C1 and C2) is important whenever some kind of "benchmarking" is intended. Transitivity means that a consistent order of *all firms* in one dimension only is possible.